OPTICAL BISTABILITY IN MOBIUS MICRORING RESONATOR

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Dedicated with my deepest love and affection to
my family
For their supports and blessings

To all my friends specially Nurul Faridah
For their motivational support

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ABSTRACT

Optical bistability is one of the nonlinear properties that produce an essential light control which contributes in various photonics applications such as all-optical switching and optical memory. In this thesis, bistability behavior of optical signals generated in microring resonator (MRR) systems using bright soliton input pulses with 1.55 μm wavelength is studied. The generation of the bistable signals is mathematically analyzed through the transfer matrix analysis and simulated by the MATLAB software version 2014a. The behavior of the propagated input pulses in terms of intensity and phase shift is investigated for different configurations including All-pass MRR, Add-drop MRR and PANDA MRR systems. Three novel Mobius MRR configurations consist of All-pass Mobius MRR, Add-drop Mobius MRR and PANDA Mobius MRR configurations are proposed and the light treatment through Mobius MRR systems is analytically studied and compared with conventional MRR systems. For determining the effect of physical parameters such as ring radius, control power variation and coupling coefficients on the output pulse, the optical hysteresis loops of bistable signals are generated via silicon-on-insulator nonlinear MRR configurations. The analyses of the results are conducted by calculating the output switching power, input threshold power and hysteresis width of bistable loop for radius variation from 1 μm to 6 μm with an increment of 1 μm, change of coupling coefficient from 0.4 to 0.9 with increment of 0.1 and variation of controlled power from 50 mW to 100 mW with increment of 10 mW. It is found that small coupling coefficients enhance the hysteresis width and output switching power of optical bistable loops. The value of output switching power obtained at the output port of Add-drop Mobius MRR is 30.26 mW which is higher than those obtained from All-pass Mobius and PANDA Mobius MRR configurations. The threshold powers of the All-pass Mobius, Add-drop Mobius and PANDA Mobius configurations for on switching operations are obtained as 20.59 mW, 31.39 mW and 25.19 mW respectively. It is found that, optimization of the Mobius MRR system can be conducted by increasing the external radius of Mobius ring waveguide and decreasing the coupling coefficient with implementation of the high control power. In this work, the Mobius configurations are introduced as a convenient compact design to generate optical bistability in comparison with conventional configurations of nonlinear MRR system.

ABSTRAK

Optik dwikestabilan adalah salah satu daripada sifat-sifat tak linear yang menghasilkan kawalan cahaya penting yang menyumbang dalam pelbagai kegunaan fotonik seperti semua-pensuisan optik dan memori optik. Dalam tesis ini, tingkah laku dwikestabilan isyarat optik yang dihasilkan dalam sistem pengalun cincin mikro (MRR) menggunakan denyut input soliton cerah dengan panjang gelombang 1.55 μm telah dikaji. Penjanaan isyarat dwistabil dianalisis secara matematik melalui analisis matriks pindahan dan disimulasikan dengan perisian MATLAB versi 2014a. Kelakuan denyut input rambatan dikaji dari segi keamatan dan anjakan fasa untuk susunan yang berbeza termasuk sistem MRR lepasan-semua, MRR penambah-jatuh dan MRR PANDA. Tiga susunan MRR Mobius baru terdiri daripada susunan MRR Mobius lepasan-semua, MRR Mobius penambah-jatuh dan MRR Mobius PANDA dicadangkan dan rawatan cahaya melalui sistem MRR Mobius dikaji secara analitik dan dibandingkan dengan sistem MRR konvensional. Untuk menentukan kesan parameter fizikal seperti perubahan jejari cincin, kuasa kawalan dan pekali gandingan denyut output, gelung histerisis optik isyarat dwistabil telah dihasilkan melalui susunan MRR tak linear silikon-atas-penebat. Analisis keputusan dilakukan dengan pengiraan kuasa pesuisan output, kuasa ambang input dan lebar gelung histerisis dwistabil untuk perubahan jejari daripada 1 μm hingga 6 μm dengan kenaikan 1 μm, perubahan pekali gandingan daripada 0.4 kepada 0.9 dengan kenaikan 0.1 dan perubahan kuasa kawalan daripada 50 mW kepada 100 mW dengan kenaikan 10 mW. Ia didapati bahawa pekali gandingan kecil meningkatkan lebar histerisis dan kuasa pensuisan output gelung optik dwistabil. Nilai kuasa pensuisan output diperolehi di port output MRR Mobius penambah-jatuh ialah 30.26 mW yang mana lebih tinggi daripada susunan MRR Mobius lepasan-semua dan MRR Mobius PANDA. Kuasa ambang susunan Mobius lepasan-semua, Mobius penambah-jatuh dan Mobius PANDA untuk operasi pensuisan terpasang diperoleh masing-masing sebagai 20.59 mW, 31.39 mW dan 25.19 mW. Ia didapati bahawa, pengoptimuman sistem Mobius MRR boleh dilakukan dengan meningkatkan jejari luar pemandu-gelombang cincin Mobius, dan mengurangkan pekali gandingan dengan pelaksanaan kuasa kawalan yang tinggi. Dalam kerja ini, susunan Mobius diperkenalkan sebagai reka bentuk padat yang mudah untuk menjana dwikestabilan optik berbanding dengan susunan konvensional pada sistem MRR tak linear.